

## Sound

**Sound:** Sound is a form of energy which produces a sensation of hearing in our ears. Sound is produced when objects vibrate. We hear sounds from various sources like humans, birds, machines, television etc. Sound travels in the form of waves.

**PROPAGATION OF SOUND:** Sound is produced by vibrating objects. The matter or substance through which sound is transmitted is called medium. It can be solid, liquid or a gas. When an object vibrates, it sets the particles of the medium around it vibrating. As a result, the adjacent particle gets displaced from its position. A series of compressions and rarefactions are set up in the air and sound is propagated through the air. When these compressions and rarefactions reach the ear drum, it vibrates and we hear the sound.

**Wave:** A wave is a vibratory disturbance in a medium which carries energy from one point to another. When a wave passes through a medium, the medium itself does not move along the direction of the wave, only the particles of the medium vibrate about their positions. There are two types of waves namely:

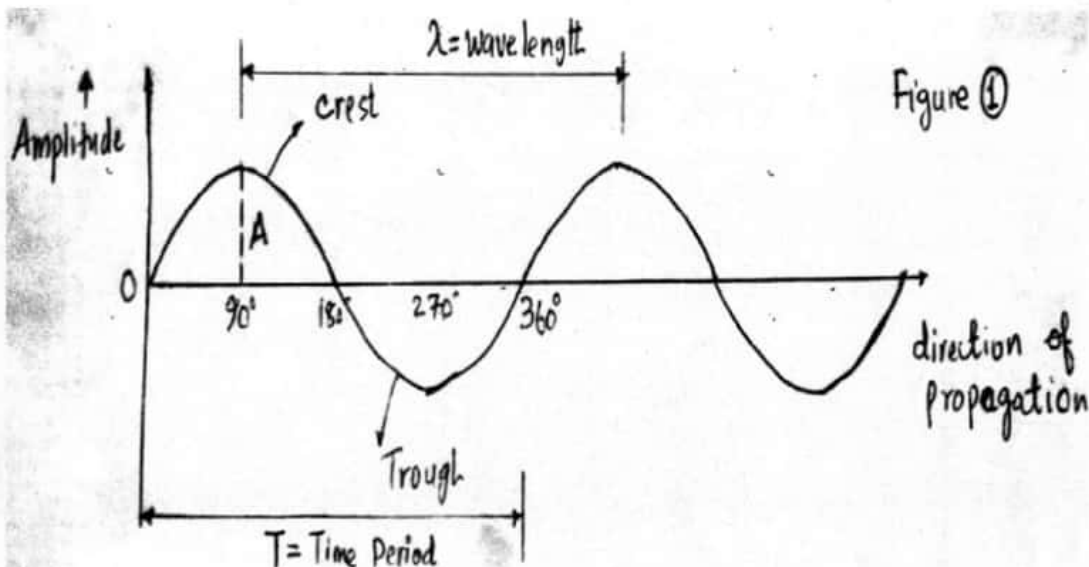
Longitudinal waves and Transverse waves.

**NATURE OF SOUND:** Sound travels in the form of waves. Sound waves are longitudinal waves.

**Longitudinal WAVES:** A wave in which the particles of the medium vibrate back and forth in the same direction in which the wave is moving called a longitudinal wave. The direction of vibration of the particles is parallel to the direction of wave. Longitudinal waves can be produced in solids, liquids and gases. The wave produced by compressing a spring is an example of longitudinal wave.

A longitudinal wave travels through a medium forming compressions and rarefactions.

A **compression** is a region of the medium in which particles are compressed i.e. particles come closer. A **rarefaction** is a region of the medium in which particles are rarefied i.e. particles get farther apart than their normal distance. Compression is indicated by C and rarefaction by R.



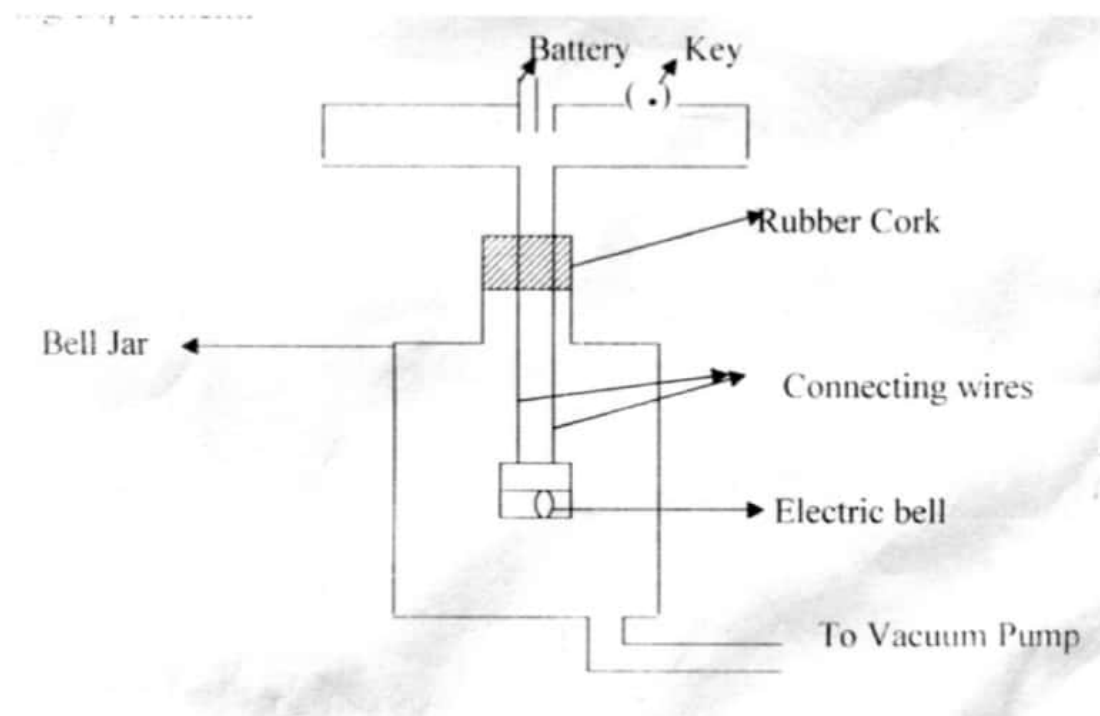
**TRANSVERSE WAVE:** A wave in which particles of the medium vibrate about their mean position in a direction perpendicular to the direction of the propagation of wave is called transverse wave. These waves propagate in solids and liquids. The waves set up in water by dropping a stone and light wave are examples of Transverse waves. A transverse wave passes through a medium forming crests and troughs. A **crest** is a portion of the medium, which is raised temporarily above the normal position of rest of the particles of medium. A **trough** is a portion of the medium, which is depressed temporarily below the normal position of rest of the particles of the medium.

**Vibration:** It is a kind of rapid to and fro motion of an object about its central position.

e.g.

1. A stretched rubber band when plucked vibrates and produces sound.
2. Sound is produced when vocal cords of humans vibrate.

**SOUND NEEDS A MEDIUM TO TRAVEL:** Sound wave needs a medium like, air, water etc. for its propagation. It cannot travel through vacuum, which can be demonstrated by the following experiment



**Activity to demonstrate that sound needs a material medium for its propagation:**

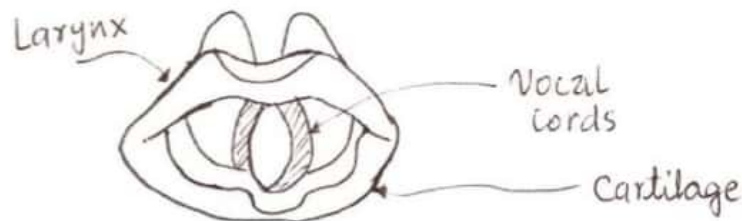
Sound requires a material medium for propagation. If there is no material medium between two points as in vacuum, sound cannot travel from one point to another. This can be demonstrated with the help of following experiment.

Take a bell jar and fix a rubber cork above it. Pass stout copper wires. Connect the bell to the electric circuit as shown in figure above. When the key is closed, the bell starts ringing and we hear its sound. Place the jar on the receiver of the exhaust pump. As the pump goes on removing air from the jar, a partial vacuum is being created in the jar. At this stage, we do



not hear any sound though the hammer can be seen striking against the gong. Thus, a material medium is always necessary for the propagation of sound.

**Sound Produced by Humans:-** The sound in humans is produced by the voice box that is also known as larynx. The voice box is situated at the upper end of the wind pipe. There are two vocal chords which are stretched across the voice box in such a way that it leaves a narrow slit between them for the passage of air. When the lungs force air through the slit, the vocal cords vibrate producing sound. Muscles attached to the vocal cords can make the cords tight or loose. When the vocal cords are tight and thin type or quality of voice is different from that when they are loose and thick.



**CHARACTERISTICS OF A SOUND WAVE:** A sound wave can be described completely by five characteristics: Wavelength, Amplitude, Time-period, Frequency and Velocity. Consider a longitudinal sound wave by the vibrations of a tuning fork.

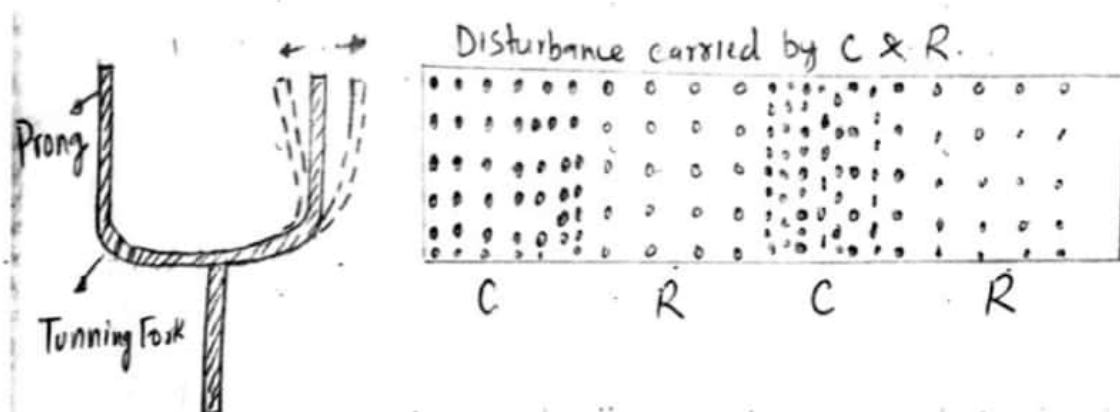


FIGURE 2

**WAVELENGTH:** In a sound wave, the distance between the centers of two consecutive compressions or two consecutive rarefactions is called its wavelength. The S.I unit of measuring wavelength is meter. Wavelength is denoted by a Greek letter  $\lambda$  (**lambda**).

**AMPLITUDE:** The maximum displacement of the particles of the medium from their original undisturbed position when a wave passes through the medium is called amplitude of the wave. Amplitude is used to describe the size of wave. It is represented by A. SI unit of amplitude is metre.

**Time PERIOD:** The time required to produce one complete wave is called time-period of the wave. It can also be defined as time taken to complete one vibration. Time-period is measured in seconds.

**FREQUENCY:** The number of complete waves produced in one second is called frequency of the wave. If ten complete waves are produced in one second, then the frequency of the waves will be 10 hertz. The S.I unit of frequency is hertz written as Hz. 1 hertz is equal to 1 vibration per second. 1 kHz is 1000 Hz. The frequency of a wave is denoted by  $f$ . Sometimes frequency is denoted by Greek letter -  $\nu$ . The frequency of a wave is the reciprocal of its time-period.

$$\text{Frequency} = \frac{1}{\text{Time-period}} \quad \text{or } f = 1/t$$

**VELOCITY:** The distance travelled by a wave in one second is called velocity of the wave. The S.I unit of velocity of wave is meter per second.

**RELATION BETWEEN VELOCITY, FREQUENCY AND WAVELENGTH OF A WAVE:**

Suppose a wave travels a distance  $\lambda$  ( ) which is its wave length in time  $t$  then velocity of wave is distance divided by time i.e. distance/time

Or,  $v = \lambda/t$

$$V = \lambda \cdot 1/t$$

$$V = \lambda f \quad (1/t = f)$$

In other words, velocity of a wave = wavelength  $\times$  frequency

This is known as **wave equation**.

**CHARACTERISTICS OF SOUND:** A sound has three characteristics: loudness, pitch and quality (or timbre)

**LOUDNESS:** The loudness of sound is a measure of the sound energy reaching the ear per second. The loudness of sound depends on the amplitude of sound waves. If the sound waves have small amplitude, then the sound will be faint or soft. On the other hand, if the amplitude is large then sound will be loud. When a table is hit hard, greater energy is supplied, table vibrates with a large amplitude and hence produces a loud sound. Loudness is measured in (**decibel**) written as dB. The softest sound is zero dB.

**PITCH:** Pitch is that characteristic of sound by which we can distinguish between different sounds of same loudness. The pitch of a sound depends on the frequency of vibration. Sounds of low frequency have low pitch and sounds of high frequency have high pitch. A man's voice and a woman's voice differ in pitch. A

man's voice is flat having low pitch, whereas a woman's voice is shrill having a high pitch.

**QUALITY OR TIMBRE:** It is that characteristic of musical sound which enables us to distinguish between the sounds of same pitch and loudness produced by different musical instruments. This characteristic depends on the shape of sound wave. The sounds produced by different musical instruments like violin, piano, sitar etc. can be distinguished by their quality.

**SPEED OF SOUND:** The speed of sound is different for different mediums. The speed of sound depends on properties of medium through which it travels. It also depends on the temperature and pressure of medium. The speed of sound decreases as we go from solid to gaseous state. Speed increases if we **increase the temperature** of the medium e.g., the speed of sound in air is 331 m/s at 0°C and 344 m/s at 22°C. In general, sound travels slowest in



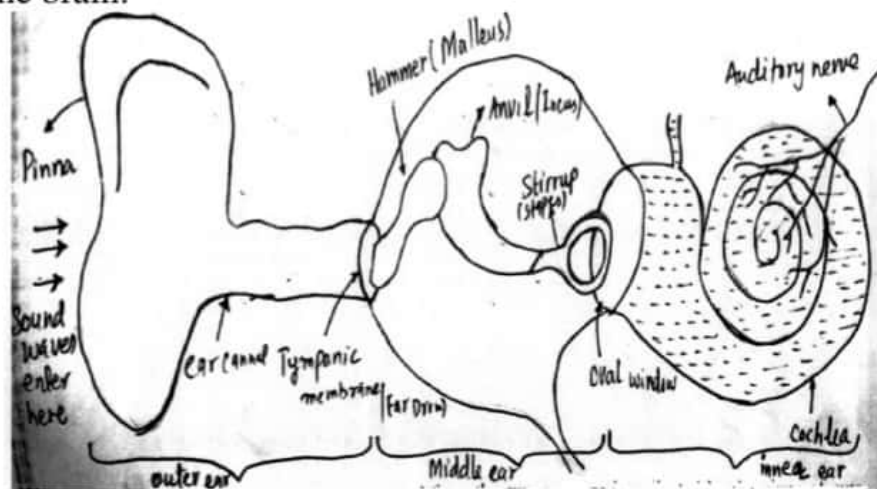
gases, faster in liquids and fastest in solids. The speed of sound in water is 1498m/s and speed of sound in solids (Iron, Steel) is 5000m/s.

**RANGE OF HEARING IN HUMANS:** The sounds in our environment have different frequencies. The sounds of all frequencies cannot be heard by the human beings. The range of frequency from 20hertz to 20000Hz is known as the frequency range of hearing in humans. The sound which we are able to hear is called **audible range**. The audible range of sound frequencies for human ear is from 20hertz to 20000hertz. Thus human ear can't hear sounds which have frequency less than 20hertz or greater than 20000hertz.

**INFRASONIC SOUNDS:** The sounds of frequencies lower than 20hertz are known as **infrasonic sounds**. These are low frequency sounds. Infrasonic sounds are produced by those objects which vibrate slowly, for example, a vibrating simple pendulum produces infrasonic sounds which we cannot hear. It is observed that some birds and animals start running here and there just before the earthquake occurs. This is because, before main shock waves, the earthquake produces low-frequency infrasonic sounds which some animals can hear and get disturbed.

**ULTRASONIC SOUNDS:** The sounds of frequencies higher than 20000hertz are known as ultrasonic sounds. These are high frequency sounds. Ultrasonic sounds cannot be heard by human beings. Dogs can hear sounds of frequency up to 50000hertz. Monkeys, deer, cats, dolphins can hear ultrasonic sounds. Bats can hear sounds having frequencies up to 120000hertz. Bats can also produce ultrasonic sounds while screaming. We cannot hear screaming of a bat because; its screams have frequency much higher than 20000hertz which is beyond our limit of hearing. Children under the age of 5 years can hear ultrasonic sounds of frequency up to 25000hertz.

**THE HUMAN EAR:** The ears are the sense organs which help us in hearing sound. The ear consists of three compartments: outer ear, middle ear and inner ear. The part of ear which we see outside the head is called outer ear. The outer ear consists of a broad part called **pinna** and about 2cm to 3 cm long passage called ear canal. At the end of ear canal is a thin, elastic and circular membrane called **ear-drum** or **tympanum**. Middle ear contains three small bones called **hammer**, **anvil** and **stirrup**. The inner ear has a coiled tube called **cochlea**. One end of cochlea is connected to the middle ear and the other to auditory nerve which goes into the brain.



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**WORKING OF HUMAN EAR:** The sound from the surroundings is collected by the pinna of outer ear. These sound waves pass through ear canal and fall on the ear drum. When the compression of sound wave strikes the ear drum, the pressure on the outside of ear drum increases and pushes it inwards. When rarefactions fall on ear drum, the pressure on outside of ear-drum decreases and it moves outwards. Thus ear drum starts vibrating back and forth. The vibrating ear drum causes small bone hammer to vibrate. Vibrations are passed to second bone anvil and finally to the third bone stirrup. The function of three bones is to amplify (make stronger) the vibrations of ear drum. The vibrations are passed to a liquid in the cochlea. The vibrating liquid of cochlea sets up electrical signals in the nerve cells and sends these signals to the brain. The brain interprets these signals as sound and we set the sensation of hearing.

**Noise Pollution:-** Any undesirable sound is termed as noise. Noise pollution is accessible, displeasing human, animal or machine created environmental noise that disrupts the activity or balance of human or animal life. The source of most outdoor noise worldwide is mainly --- construction and transport systems including motor vehicle noise, air craft noise and train noise. Poor urban planning may give rise to noise pollution. Indoor and outdoor noise pollution sources include vehicles, mega phone's etc.

**Effects:-** The unwanted sound can damage physiological health. It can cause aggression, hypertension, hearing loss, sleep disturbances and other harmful effects. High noise levels can contribute to cardiovascular effects and increase incidence of coronary artery disease.

- ✓ Draw diagrams on Fair Note Books.
- ✓ Do questions of textbook on Fair Note Books.

### Textual questions

**Do Q1 to Q7 yourself**

**8.**

Noise	Music
It is an unpleasant sound.	It is a pleasant sound.
It causes discomfort.	It has soothing effect.
It interferes with the Physiological and psychological functions of the body.	It does not do so.